

## Claims

What is claimed is:

- 1           1.     A method for implementing a next generation synchrotron light  
2 source comprising the steps of:  
3           providing first electron beam source modules for producing a first  
4 electron beam;  
5           providing initial electron beam source modules for producing multiple  
6 harmonic wavelength photons;  
7           combining said multiple harmonic wavelength photons with said first  
8 electron beam;  
9           providing selected radiation production modules for generating  
10 fundamental and nonlinear harmonics of said combined electron beam to be  
11 used as the next generation synchrotron light source or as a coherent seed  
12 for additional selected modules.
- 1           2.     A method for implementing a next generation synchrotron light  
2 source as recited in claim 1 wherein the step of providing initial electron  
3 beam source modules for producing multiple harmonic wavelength photons  
4 includes the steps of providing an electron gun and an accelerating structure  
5 for producing an electron beam; said accelerating structure receiving emitted  
6 electrons from said electron gun and raising electron beam energy.
- 1           3.     A method for implementing a next generation synchrotron light  
2 source as recited in claim 2 wherein the step of providing initial electron  
3 beam source modules for producing multiple harmonic wavelength photons  
4 further includes the steps of providing an electron bunch compressor for  
5 prebunching said electron beam to increase an electron bunch peak current,  
6 providing a seed laser beam and coupling in an undulator said seed laser  
7 beam with said prebunched electron beam.

1           4.     A method for implementing a next generation synchrotron light  
2 source as recited in claim 3 wherein the step of providing initial electron  
3 beam source modules for producing multiple harmonic wavelength photons  
4 further includes the steps of providing a radiation production section  
5 receiving said seed laser beam coupled with said prebunched electron beam  
6 for producing multiple harmonic wavelength photons.

1           5.     A method for implementing a next generation synchrotron light  
2 source as recited in claim 1 wherein the step of providing first electron beam  
3 source modules for producing said first electron beam includes the steps of  
4 providing an electron gun, an electron accelerating structure coupled to said  
5 electron gun and an electron bunch compressor coupled to said electron  
6 accelerating structure for producing said first electron beam.

1           6.     A method for implementing a next generation synchrotron light  
2 source as recited in claim 1 wherein the step of providing selected radiation  
3 production modules for generating fundamental and nonlinear harmonics of  
4 said combined electron beam includes the steps of providing a first amplifier  
5 module and a second amplifier module coupled to said first amplifier module;  
6 applying a seed laser beam  $\lambda_{\text{fund}}$  and a first electron beam to said first  
7 amplifier module; generating fundamental  $\lambda_{\text{fund}}$  and a predefined nonlinear  
8 harmonics  $\lambda_{\text{seed(predefined)}}$  in said first amplifier module; and applying a  
9 second electron beam and said predefined nonlinear harmonics  
10  $\lambda_{\text{seed(predefined)}}$  to said second amplifier module that is used as a coherent  
11 seed for said second amplifier module; and generating fundamental  $\lambda_{\text{fund}}$   
12 and said predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$  in said second  
13 amplifier module.

1           7.     A method for implementing a next generation synchrotron light  
2 source as recited in claim 6 wherein the step of providing selected radiation  
3 production modules for generating fundamental and nonlinear harmonics of  
4 said combined electron beam further includes the steps of providing a third  
5 amplifier module coupled to said second amplifier module and a fourth  
6 amplifier module coupled to said third amplifier module; applying a third  
7 electron beam and said predefined nonlinear harmonic  $\lambda_{\text{seed(predefined)}}$  from  
8 said second amplifier module to said third amplifier module that is used as a  
9 coherent seed for said third amplifier module; generating fundamental  $\lambda_{\text{fund}}$   
10 and said predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$  in said third  
11 amplifier module; and applying a fourth electron beam and said predefined  
12 nonlinear harmonic  $\lambda_{\text{seed(predefined)}}$  from said third amplifier module to said  
13 fourth amplifier module that is used as a coherent seed for said fourth  
14 amplifier module; and generating fundamental and said predefined nonlinear  
15 harmonics in said fourth amplifier to be used as the next generation  
16 synchrotron light source.

1           8.     A method for implementing a next generation synchrotron light  
2 source as recited in claim 6 wherein the step of providing selected radiation  
3 production modules for generating fundamental and nonlinear harmonics of  
4 said combined electron beam includes the steps of providing a high-gain  
5 harmonic generation (HGHG) module; said HGHG module including a  
6 modulative section, a dispersive section and a radative section; applying a  
7 third electron beam and said generated fundamental  $\lambda_{\text{fund}}$  and said  
8 predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$  from said second amplifier  
9 module to said high-gain harmonic generation (HGHG) module.

1           9.     A method for implementing a next generation synchrotron light  
2 source as recited in claim 8 wherein the step of providing selected radiation  
3 production modules for generating fundamental and nonlinear harmonics of  
4 said combined electron beam further includes the steps of generating  
5 fundamental and said predefined nonlinear harmonic in said high-gain  
6 harmonic generation (HGHG) module to be used as the next generation  
7 synchrotron light source.

1           10.    A method for implementing a next generation synchrotron light  
2 source as recited in claim 1 wherein the step of providing selected radiation  
3 production modules for generating fundamental and nonlinear harmonics of  
4 said combined electron beam includes the steps of providing a first amplifier  
5 module and a high-gain harmonic generation (HG HG) module coupled to  
6 said first amplifier module; applying a seed laser beam  $\lambda_{\text{fund}}$  and a first  
7 electron beam to said first amplifier module; generating fundamental  $\lambda_{\text{fund}}$   
8 and a predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$  in said first amplifier  
9 module; and applying a second electron beam and said predefined nonlinear  
10 harmonic  $\lambda_{\text{seed(predefined)}}$  from said first amplifier module to said high-gain  
11 harmonic generation (HG HG) module that is used as a coherent seed for  
12 said high-gain harmonic generation (HG HG) module.

1           11.    A method for implementing a next generation synchrotron light  
2 source as recited in claim 1 wherein the step of providing selected radiation  
3 production modules for generating fundamental and nonlinear harmonics of  
4 said combined electron beam further includes the steps of generating  
5 fundamental  $\lambda_{\text{fund}}$  and said predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$   
6 in said high-gain harmonic generation (HG HG) module to be used as the  
7 next generation synchrotron light source.

1           12. A method for implementing a next generation synchrotron light  
2 source as recited in claim 1 wherein the step of providing selected radiation  
3 production modules for generating fundamental and nonlinear harmonics of  
4 said combined electron beam includes the steps of providing a first high-gain  
5 harmonic generation (HGHG) module and a second high-gain harmonic  
6 generation (HGHG) module coupled to said first high-gain harmonic  
7 generation (HGHG) module; applying a seed laser beam  $\lambda_{\text{fund}}$  and a first  
8 electron beam to said first high-gain harmonic generation (HGHG) module;  
9 generating fundamental  $\lambda_{\text{fund}}$  and a predefined nonlinear harmonics  
10  $\lambda_{\text{seed(predefined)}}$  in said first high-gain harmonic generation (HGHG) module;  
11 and applying a second electron beam and said predefined nonlinear  
12 harmonic  $\lambda_{\text{seed(predefined)}}$  to said second high-gain harmonic generation  
13 (HGHG) module that is used as a coherent seed for said second high-gain  
14 harmonic generation (HGHG) module; and generating fundamental  $\lambda_{\text{fund}}$  and  
15 said predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$  in said second high-gain  
16 harmonic generation (HGHG) module to be used as the next generation  
17 synchrotron light source.

1           13. A method for implementing a next generation synchrotron light  
2 source as recited in claim 1 wherein the step of providing selected radiation  
3 production modules for generating fundamental and nonlinear harmonics of  
4 said combined electron beam includes the steps of providing selected  
5 radiation production modules for producing the next generation synchrotron  
6 light source by a three step process including imprinting, upconverting or  
7 wavelength shifting and reinforcing or strengthening of said combined  
8 electron beam.

1           14. A method for implementing a next generation synchrotron light  
2 source as recited in claim 13 wherein the steps of imprinting of said  
3 combined electron beam includes the steps of receiving a seed laser beam  
4 and a first electron beam in an undulator for providing a specified amount of  
5 energy modulation and using a bunch compressor for overbunching of said  
6 electron beam.

1           15. A method for implementing a next generation synchrotron light  
2 source as recited in claim 14 wherein the step of upconverting or wavelength  
3 shifting of said combined electron beam includes the steps of applying said  
4 overbunched electron beam to an accelerating section to induce an energy  
5 chirp to said electron beam; and compressing said electron beam using a  
6 second bunch compressor.

1           16. A method for implementing a next generation synchrotron light  
2 source as recited in claim 15 wherein the step of reinforcing or strengthening  
3 of said combined electron beam includes the steps of removing said energy  
4 chirp from said electron beam in a second accelerating section; injecting said  
5 resulting electron beam to a radiation production module to use harmonic  
6 content of said electron beam.

1           17. A method for implementing a next generation synchrotron light  
2 source as recited in claim 16 wherein the step of injecting said electron  
3 beam to a radiation production module includes the step of injecting said  
4 resulting electron beam into an undulator (amplifier), two-undulator harmonic  
5 generation schemes (TUHGS) or a high-gain harmonic generation (HGHG)  
6 module.

1           18. A modular system for implementing a next generation  
2 synchrotron light source comprising:  
3           first electron beam source modules for producing a first electron  
4 beam;  
5           initial electron beam source modules for producing multiple harmonic  
6 wavelength photons;  
7           a mixer for combining said multiple harmonic wavelength photons with  
8 said first electron beam;  
9           radiation production modules for generating fundamental and  
10 nonlinear harmonics of said combined electron beam to be used as the next  
11 generation synchrotron light source or as a coherent seed for additional  
12 selected modules.

1           19. A modular system for implementing a next generation  
2 synchrotron light source as recited in claim 18 wherein said initial electron  
3 beam source modules for producing multiple harmonic wavelength photons  
4 includes a seed laser providing a seed laser beam  $\lambda_{\text{fund}}$  and wherein said  
5 radiation production modules for generating fundamental and nonlinear  
6 harmonics of said combined electron beam include four amplifier modules  
7 connected in series, each of said four amplifier modules tuned to a  
8 fundamental resonance; said seed laser beam  $\lambda_{\text{fund}}$  and said first electron  
9 beam applied to a first amplifier module of said four series connected  
10 amplifier modules; said first amplifier module generating fundamental  $\lambda_{\text{fund}}$   
11 and a predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$ ; a second electron  
12 beam and said predefined nonlinear harmonic  $\lambda_{\text{seed(predefined)}}$  from said first  
13 amplifier module applied to a second amplifier module and used as a  
14 coherent seed for said second amplifier module; said second amplifier  
15 module generating fundamental  $\lambda_{\text{fund}}$  and said predefined nonlinear  
16 harmonics  $\lambda_{\text{seed(predefined)}}$ ; a third electron beam and said predefined  
17 nonlinear harmonic  $\lambda_{\text{seed(predefined)}}$  from said second amplifier module  
18 applied to a third amplifier module and used as a coherent seed for said third  
19 amplifier module; said third amplifier module generating fundamental  $\lambda_{\text{fund}}$   
20 and said predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$ ; and a fourth  
21 electron beam and said predefined nonlinear harmonic  $\lambda_{\text{seed(predefined)}}$  from  
22 said third amplifier module applied to a fourth amplifier module and used as  
23 a coherent seed for said fourth amplifier module; said fourth amplifier module  
24 generating fundamental  $\lambda_{\text{fund}}$  and nonlinear harmonics  $\lambda_{\text{predefined}}$  used as  
25 the next generation synchrotron light source.

1           20. A modular system for implementing a next generation  
2 synchrotron light source as recited in claim 18 wherein said initial electron  
3 beam source modules for producing multiple harmonic wavelength photons  
4 includes a seed laser providing a seed laser beam  $\lambda_{\text{fund}}$  and wherein said  
5 radiation production modules for generating fundamental and nonlinear  
6 harmonics of said combined electron beam include a first high-gain harmonic  
7 generation (HGHG) module and a second high-gain harmonic generation  
8 (HGHG) module connected in series; said seed laser beam  $\lambda_{\text{fund}}$  and said  
9 first electron beam applied to said first high-gain harmonic generation  
10 (HGHG) module; said first high-gain harmonic generation (HGHG) module  
11 inducing energy modulation and spatial bunching in respective modulative  
12 and radiative sections; said first high-gain harmonic generation (HGHG)  
13 module generating fundamental  $\lambda_{\text{fund}}$  and a predefined nonlinear harmonics  
14  $\lambda_{\text{seed(predefined)}}$ ; a second electron beam and a predefined nonlinear  
15 harmonic  $\lambda_{\text{seed(predefined)}}$  from said first high-gain harmonic generation  
16 (HGHG) module applied to said second high-gain harmonic generation  
17 (HGHG) module; and said second high-gain harmonic generation (HGHG)  
18 module producing a longitudinally coherent output radiation in said  
19 fundamental  $\lambda_{\text{fund}}$  and said predefined nonlinear harmonics  $\lambda_{\text{predefined}}$  used  
20 as the next generation synchrotron light source.



21. A modular system for implementing a next generation synchrotron light source as recited in claim 18 wherein said initial electron beam source modules for producing multiple harmonic wavelength photons includes a seed laser providing a seed laser beam  $\lambda_{\text{fund}}$  and wherein said radiation production modules for generating fundamental and nonlinear harmonics of said combined electron beam include a first amplifier module and a second amplifier module connected in series and a high-gain harmonic generation (HGHG) module connected to said second amplifier module; said seed laser beam  $\lambda_{\text{fund}}$  and said first electron beam applied to said first amplifier module; said first amplifier module generating fundamental  $\lambda_{\text{fund}}$  and a predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$ ; a second electron beam and said predefined nonlinear harmonic  $\lambda_{\text{seed(predefined)}}$  from said first amplifier module applied to said second amplifier module and used as a coherent seed for said second amplifier module; said second amplifier module generating fundamental  $\lambda_{\text{fund}}$  and said predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$ ; a third electron beam and said predefined nonlinear harmonic  $\lambda_{\text{seed(predefined)}}$  from said second amplifier module applied to said high-gain harmonic generation (HGHG) module; said high-gain harmonic generation (HGHG) module including a modulative section to induce predefined energy modulation in said third electron beam; and a radiative section tuned to said predefined nonlinear harmonic  $\lambda_{\text{seed(predefined)}}$  from said second amplifier module and producing a longitudinally coherent output radiation in said predefined nonlinear harmonic  $\lambda_{\text{predefined}}$  used as the next generation synchrotron light source.

1           22. A modular system for implementing a next generation  
2 synchrotron light source as recited in claim 18 wherein said initial electron  
3 beam source modules for producing multiple harmonic wavelength photons  
4 includes a soft x-ray seed laser providing a seed laser beam  $\lambda_{\text{fund}}$  and  
5 wherein said radiation production modules for generating fundamental and  
6 nonlinear harmonics of said combined electron beam include an amplifier  
7 module and a high-gain harmonic generation (HG) module connected to  
8 said amplifier module; said seed laser beam  $\lambda_{\text{fund}}$  and said first electron  
9 beam applied to said amplifier module; said amplifier module generating  
10 fundamental  $\lambda_{\text{fund}}$  and a predefined nonlinear harmonics  $\lambda_{\text{seed(predefined)}}$ ; a  
11 second electron beam and said predefined nonlinear harmonic  
12  $\lambda_{\text{seed(predefined)}}$  from said first amplifier module applied to said high-gain  
13 harmonic generation (HG) module; said high-gain harmonic generation  
14 (HG) module producing a longitudinally coherent output radiation in said  
15 predefined nonlinear harmonic  $\lambda_{\text{predefined}}$  used as the next generation  
16 synchrotron light source.

1           23. A modular system for implementing a next generation  
2 synchrotron light source as recited in claim 18 wherein said initial electron  
3 beam source modules for producing multiple harmonic wavelength photons  
4 includes a soft x-ray seed laser providing a seed laser beam  $\lambda_{\text{fund}}$  and  
5 wherein said radiation production modules for generating fundamental and  
6 nonlinear harmonics of said combined electron beam include selected  
7 radiation production modules for producing the next generation synchrotron  
8 light source including functions for imprinting, upconverting or wavelength  
9 shifting and reinforcing or strengthening of said combined electron beam.

1           24. A modular system for implementing a next generation  
2 synchrotron light source as recited in claim 23 wherein said imprinting  
3 function for imprinting of said combined electron beam includes an undulator  
4 for receiving a seed laser beam and a first electron beam and for providing a  
5 specified amount of energy modulation and a bunch compressor for  
6 overbunching of said electron beam; wherein said upconverting or  
7 wavelength shifting function includes an accelerating section receiving said  
8 overbunched electron beam to induce an energy chirp to said electron  
9 beam; and a second bunch compressor compressing said electron beam;  
10 and wherein said reinforcing or strengthening function for reinforcing or  
11 strengthening of said combined electron beam includes a second  
12 accelerating section for removing said energy chirp from said electron beam;  
13 a radiation production module receiving said resulting electron beam to use  
14 harmonics of said electron beam.

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